# Femtotechnology. AB-matter. Properties, Possibility Production and Applications

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## Abstract

Designs of new forms of matter composed of nucleons (neutrons, protons), electrons, and other nuclear particles are detailed. This matter is measured in the femtometer ($10^{-15}$ m) scale ("femtotechnology"), which is millions of times smaller than material on the nanometer ($10^{-9}$ m) scale ("nanotechnology"). This new Femtotubes has extraordinary properties such as tensile strength, stiffness, hardness, critical temperature, superconductivity, super-transparency and zero friction. All of these properties are magnified millions of times in comparison to those of conventional molecular matter. Applications include concepts of design for aircraft, ships, transportation, thermonuclear reactors, constructions, and so on from nuclear matter. These vehicles will have unbelievable possibilities such as invisibility, ghost-like penetration through any walls and armor, protection from nuclear bomb explosions and any radiation flux.

**Key words**: femtotechnology, nuclear matter, artificial AB-Matter, Femtotubes, super strength matter, superthermal resistance, invisible matter, super-protection from nuclear explosion and radiation.

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## Introduction

In conventional matter made of atoms and molecules the nucleons (protons, neutrons) are located in the nucleus, but the electrons rotate in orbits around nucleus in distance in millions times more than diameter of nucleus. Therefore, in essence, what we think of as solid matter contains a --relatively! --'gigantic' vacuum (free space) where the matter (nuclei) occupies but a very small part of the available space. Despite this unearthly emptiness, when you compress this (normal, non-degenerate) matter the electrons located in their orbits repel atom from atom and resist any great increase of the matter's density. Thus it feels solid to the touch.

The form of matter containing and subsuming all the atom's particles into the nucleus is named *degenerate matter*. Degenerate matter is found in white dwarfs, neutron stars and black holes. In nature, degenerate matter exists stably to our knowledge only in large astronomical masses because degenerate matter *suddenly* removed from this hypergravitized condition would explosively resume non-degenerate form.

## Innovations and computations

Designs of artificial small masses of synthetic degenerate matter which can exist at Earth-normal temperatures and pressures are proposed. Such stabilized degenerate matter in small amounts does not exist in Nature as far as we know, but, nanotubes do not exist in nature either. As the closest to this innovation is nanotubes, this material could have been called femtotubes but our designs are not only tubular in form but also of an extremely thin strong thread (fiber, filament, string), round bar, and net (dense or non dense weave and mesh size) so we name this matter AB-Matter. Some possible forms of AB-Matter are shown in fig.1. Proposed technologies are below. The threads from AB-Matter are stronger by millions of times than normal materials. They can be inserted as reinforcements, into conventional materials, which serve as a matrix, and are thus strengthened by thousands of times (see computation section).

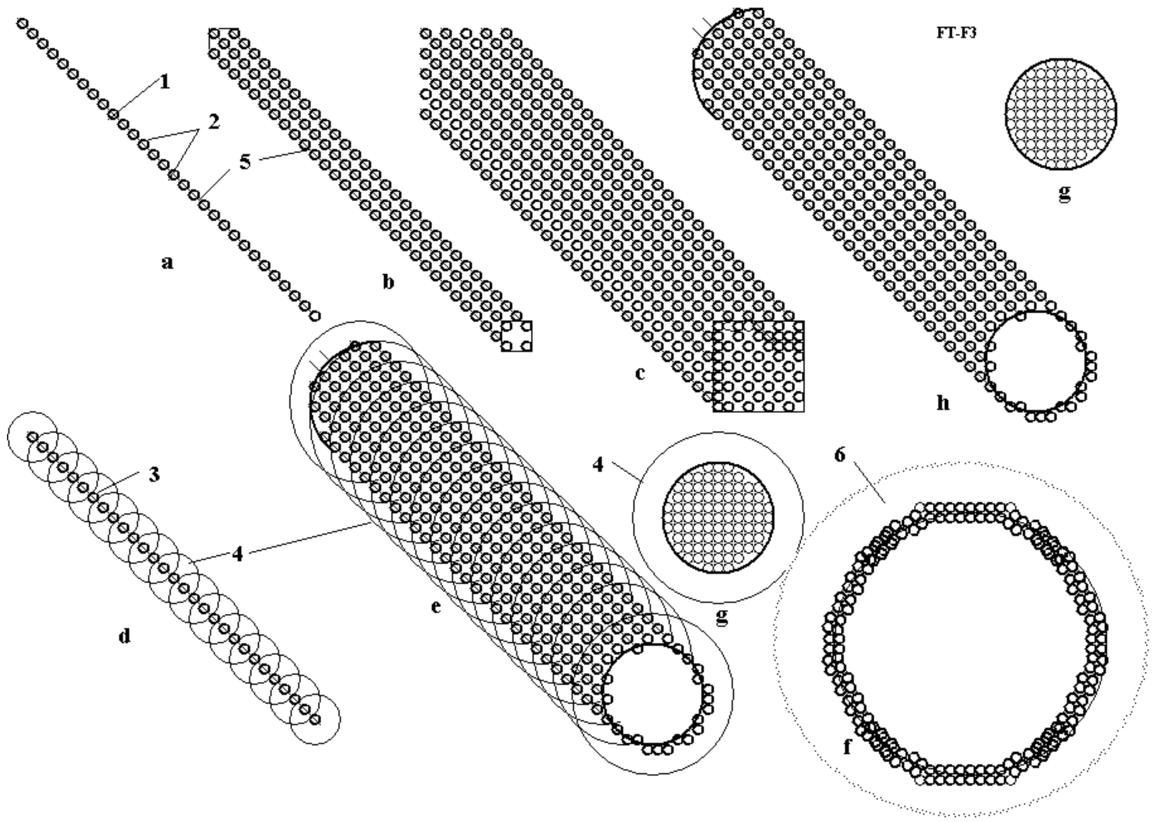



**Fig.1**. Design of AB-Matter from electrons and nucleons (neutrons, protons, etc.). (**a**) linear one string (monofilament) (fiber, whisker, filament, thread); (**b**) ingot from four nuclear monofilaments; (**c**) multi-ingot from nuclear monofilament; (**d**) string made from protons and neutrons with electrons rotated around monofilament; (**e**) single wall femto tube (SWFT) fiber with rotated electrons; (**f**) cross-section of multi wall femto tube (MWFT) string; (**g**) cross-section of rod; (**h**) - single wall femto tube (SWFT) string with electrons inserted into AB-Matter *Notations*: 1 – nuclear string; 2 nucleons (neutrons, protons, etc.). 3 – protons; 4 – orbit of electrons; 5 – electrons; 6 – cloud of electrons around tube.

## Estimation and Computation of properties of AB-Matter

### 1. Strength of AB-Matter.

*Strength (tensile stress) of single string (*AB-Matter *monofilament).* The average connection energy of two nucleons is

$$1 \text{ eV} = 1.6\times10^{-19} \text{ J}, \quad E = 8 \text{ MeV} = 12.8\times10^{-13} \text{ J}. \qquad (1)$$

The average effective distance of the strong force is about $l$ = 2 fm =$2\times10^{-15}$ m (1 fm = $10^{-15}$ m). The average connection force $F$ the single thread is about

$$F_1 = E/l = 6.4\times10^{2} \text{ N} . \qquad (2)$$

This is worth your attention: a thread having diameter *100 thousand times less than an atom's diameter* can suspend a weight nearly of human mass. Specific ultimate tensile stress of single string for cross-section area $s = 2\times2 = 4$ fm$^2$ =$4\times10^{-30}$ m$^2$ is

$$\sigma = F/s = 1.6\times10^{32} \text{ N/m}^2. \qquad (3)$$

Compressive stress for $E$ = 30 MeV and $l$ = 0.4 fm (fig.1) is

$$\sigma = E/sl = 3\times10^{33} \text{ N/m}^2. \qquad (4)$$

The Young's modulus of tensile stress for elongation of break $\varepsilon$ =1 is

$$I = \sigma/\varepsilon = 1.6\times10^{32} \text{ N/m}^2. \qquad (5)$$

The Young's modulus of compressive stress for $\varepsilon$ =0.4 is

$$I = \sigma/\varepsilon = 7.5\times10^{33} \text{ N/m}^2. \qquad (6)$$

*Comparison to steel and nanotubes*: Stainless steel has a value of $\sigma = (0.65 - 1)\times10^9$ N/m$^2$, $I = 2\times10^{11}$ N/m$^2$ . Nanotubes has $\sigma = (1.4 \div 5)\times10^{10}$ N/m$^2$, $I = 8\times10^{11}$ N/m$^2$ . That means AB-Matter

is stronger by a factor of $10^{23}$ times than steel (by 100 thousands billion by billions times!) and by $10^{22}$ times than nanotubes (by 10 thousand billion by billions times!). Young's modulus, and the elastic modulus also are billions of times more than steel and elongation resistance a thousand times better than the elongation of steel. Strength (average tensile force) of one m thin (one layer, 1 fm) film (1 m compact net) from single strings with step size of grid $l$ = 2 fm =$2\times10^{-15}$ m is

$$F = F_1 /l = 3.2\times10^{17} \text{ N/m} = 3.2\times10^{13} \text{ tons/m}. \qquad (7)$$

Strength (average tensile force) of net from single string with step (mesh) size $l = 10^{-10}$ m (less than a molecule size of conventional matter) which does not pass the any usual gas, liquids or solid (an impermeable net, essentially a film to ordinary matter)

$$F = F_1 /l = 6.4\times10^{12} \text{ N/m} = 6.4\times10^{8} \text{ tons/m}. \qquad (8)$$

That means one meter of very thin (1 fm) net can suspend ***100 millions tons of load.***
The tensile stress of a permeable net (it will be considered later) having $l = 10^{-7}$ m is

$$F = F_1 /l = 6.4\times10^{9} \text{ N/m} = 6.4\times10^{5} \text{ tons/m}. \qquad (9)$$

## 2. Specific density and specific strength of AB-Matter.

The mass of 1 m of single string (AB-Matter**.** Monofilament) is

$$M_1 = m/l =1.67\times10^{-27}/(2\times10^{-15}) = 8.35\times10^{-13} \text{ kg}. \qquad (10)$$

where $m = 1.67\times10^{-27}$ kg is mass of one nucleon; $l = 2\times10^{-15}$ is distance between nucleons, m., the volume of 1 m one string is $v = 10^{-30}$ m$^3$. That means the specific density of AB-Matter string and compact net is

$$d = \gamma = M_1/v = 8.35\times10^{17} \text{ kg/m}^3. \qquad (11)$$

That is very high (nuclear) specific density. But the total mass is nothing to be afraid of since, the dimensions of AB-Matter string, film and net are very small and mass of them are:

a) mass of string $M_1 = 8.35\times10^{-13}$ kg (see (10)), (12)
b) mass of 1 m$^2$ solid film $M_f = M_1/l = 4.17\times10^{2}$ kg, (13)
c) mass of 1 m$^2$ impenetrable net $M_i = M_1/l = 8.35\times10^{-3}$ kg, $l = 10^{-10}$ m, (14)
d) mass of 1 m$^2$ permeable net $M_p = M_1/l = 8.35\times10^{-6}$ kg, $l = 10^{-7}$ m . (15)

As such, nets from AB-Matter have very high strength and very small mass. To provide an absolute heat shield for the Space Shuttle Orbiter that could withstand reentries dozens of times worse than today would take only ~100 kilograms of mass for 1105 square meters of surface and the offsetting supports.

The specific strength coefficient of AB-Matter-- very important in aerospace-- [3]-]5] is

$$k = \sigma/d = 1.6\times10^{32} /8.35\times10^{17} =1.9\times10^{14} \text{ (m/s)}^2 < c^2 = (3\times10^{8} )^2 = 9\times10^{16} \text{ (m/s)}^2. \qquad (16)$$

This coefficient from conventional high strong fiber has value about $k = (1 - 6) \times10^{9}$ [3]-[6]. AB-Matter is 10 million times stronger.

The specific mass and volume density of energy with AB-Matter are

$$E_v = E/v =1.6\times10^{32} \text{ J/m}^3 , \quad E_m = E/m_p =7.66\times10^{14} \text{ J/kg} . \qquad (17)$$

Here $E=12.8\times10^{-13}$ J is (1), $m_p = 1.67\times10^{-27}$ kg is nucleon mass, kg, $v = 8\times10^{-45}$ m$^3$ is volume of one nucleon. The average specific pressure may reach

$$p=F_1/s=12.8\times10^{-13}/4\times10^{-30} =3.2\times10^{-27} \text{ N/m}^2.$$

## 3. Failure temperature of AB-Matter and suitability for thermonuclear reactors.

The strong nuclear force is very powerful. That means the outer temperature which must to be reached to destroy the AB fiber, film or net is $T_e$ = 6 MeV. If we transfer this temperature in Kelvin degrees we get

$$T_k = 1.16\times10^{4}\, T_e = 7\times10^{10}\text{K}. \qquad (18)$$

That temperature is 10 thousands millions degrees. It is about 50 - 100 times more than temperature in a fusion nuclear reactor. The size and design of the fusion reactor may be small and simple (for example, without big superconductive magnets, cryogenics, etc). We can add the AB matter has zero heat/thermal conductivity (see later) and it cannot cool the nuclear plasma. This temperature is enough for nuclear reaction of the cheap nuclear fuel, for example, D + D. The AB

matter may be used in a high efficiency rocket and jet engines, in a hypersonic aircraft and so on.
No even in theory can conventional materials have this fantastic thermal resistance!

**4. Energy generated by production of AB-Matter.**

Manufacture of AB-Matter produces a large amount of nuclear energy. That energy is more than the best thermonuclear fusion reaction produces. Joining of each nucleon produces 8 MeV energy, when joining the deuterium D and tritium T (2+3=5 nucleolus) produced only 17.5 MeV (3.6 MeV for every nucleon). If we use the ready blocks of nucleons as the D=$^2$H, T=$^3$H, $^4$He, etc., the produced energy decreases. Using the ready nucleus blocks may be necessary because these reactions create the neutrons (n). For example:

$$^2H + {}^2H \rightarrow {}^3He + n + 3.27\ MeV, \quad {}^3H + {}^2H \rightarrow {}^4He + n + 17.59\ MeV\ , \qquad (19)$$

which may be useful for producing the needed AB-Matter.

Using the ready blocks of nucleons decreases the energy getting in AB-Matter production but that decreases also the cost of needed material and enormously simplifies the technology. A small part (0.7 MeV) of this needed energy will be spent to overcome the Coulomb barrier when the proton joins to proton. Connection of neutrons to neutron or proton does not request this energy (as there is no repulsion of charges). It should be no problem for current technology to accelerate the protons for energy 0,7 MeV.

For example, compute the energy in production of $m$ = 1 gram = 0.001 kg of AB-Matter.

$$E_{1g} = E_1 m/m_p = 7.66\times10^{11}\ J/g\ . \qquad (20)$$

Here $E_1$= 8 MeV= 12.8×10$^{-13}$ J – energy produced for joining 1 nucleon, $m_p$ =1.67×10$^{-27}$ kg is mass of nucleon. One kg of gasoline (benzene) produces 44 MJ/kg energy. That means that 1 g of AB-Matter requires the equivalent energy of 17.4 tons of benzene.

**5. Super-dielectric strength of AB-Matter film**.

Dielectric strength equals

$$E_d = E/l = 8\ MV/10^{-15}\ m = 8\times10^{15}\ MV/m\ . \qquad (21)$$

The best conventional material has dielectric strength of only 680 MV/m [4].

**6. AB-Matter with orbiting electrons or immersed in electron cloud.**

We considered early the AB-Matter which contains the electrons within its' own string, film or net. The strong nuclear force keeps the electron (as any conventional matter particle would) in its sphere of influence. But another method of interaction and compensation of electric charges is possible– rotation of electrons around AB-Matter string (or other linear member) or immersing the AB-Matter string (or other linear member, or AB-Matter net --) in a sea of electrons or negative charged atoms (ions). The first case is shown in fig. 3d,e,g , the second case is shown in fig. 3f.

The first case looks like an atom of conventional matter having the orbiting electron around the nucleus. However our case has a principal difference from conventional matter. In normal matter the electron orbits around the nucleus as a POINT. In our case it orbits around the charged nuclear material (AB-Matter) LINE ( some form of linear member from AB-Matter). That gives a very important difference in electrostatic force acting on the electron. In conventional cases (normal molecular matter) the electrostatic force decreases as $1/r^2$, in our AB-Matter case the electrostatic force decreases as $1/r$. The interesting result (see below) is that the electron orbit in AB-Matter does follow the usual speed relationship to radius. The proof is below:

$$\frac{mV^2}{r} = eE, \quad E = k\frac{2\tau}{r}, \quad mV^2 = 2k\tau e\ , \quad V = \sqrt{\frac{2ke\tau}{m}} = \sqrt{N_p}\, e\sqrt{\frac{2k}{m}} = 22.4\sqrt{N_p}\,, \qquad (22)$$

where $m = m_e$ = 9.11×10$^{-31}$ kg; $V$ – electron speed, m/s; $r$ is radius of electron orbit, m; $\tau$ is charge density in 1 m of single string, C/m; $E$ is electrostatic intensity, A/m or N/C; $k$ = 9×10$^9$ Nm$^2$/C$^2$ is electrostatic constant, $e$ = 1.6×10$^{-19}$ C is charge of electron, C; $N_p$ is number of proton in 1 m of

single string, 1/m. As you see from last equation (22) the electron speed is not relative to radius. The real speed will be significantly less than given equation (22) because the other electrons block the charge of the rest of the string.

The total charge of the system is zero. Therefore we can put $N_p$ =1 (every electron in orbit is kept by only one proton in string). From last equation (22) we find $V$ = 22.4 m/s. That means the electron speed carries only a very small energy. In the second case the AB-Matter (string girder) can swim in a cloud (sea) of electrons. That case occurs in metals of conventional matter. But a lattice of metallic ions fills the volume of conventional metal giving drag to electron flow (causing electrical resistance). The stringers and plate nets of AB-Matter can locate along the direction of electric flow. They constitute only a relatively tiny volume and will produce very small electric resistance. That means the AB-Matter may be quasi-super-conductivity or super-conductivity. The electrons rotate around an AB-Matter string repel one from other. The tensile force from them is

$$F = k\frac{e^2}{d^2}\left(1+\frac{1}{2^2}+\frac{1}{3^2}+...+\frac{1}{n^2}+...\right)=\frac{\pi^2 k}{6}\frac{e^2}{d^2}=1.476\cdot 10^{10}\frac{e^2}{d^2} \ . \qquad (23)$$

For distance $d = 2\times10^{-15}$ m the force equals $F$ = 10.5 N. This force keeps the string and net in unfolded stable form.

## Some Properties Of AB-Matter

We spoke about the ***fantastic tensile and compressive strength, rigidity, hardness, specific strength, thermal (temperature) durability, thermal shock, and enormous elongation of*** AB-Matter, there are other almost miraculous properties:

1. *Zero heat/thermal capacity*. That follows because the mass of nucleons (AB-Matter string, film, net) is very small and nucleons have a very strong connection one to other. Conventional atoms and molecules cannot pass their paltry energy to AB-Matter! That would be equivalent to moving a huge dry-dock door of steel by impacting it with very light table tennis balls.

2. *Zero heat/thermal conductivity*. (See above).

3. *Absolute chemical stability*. *No corrosion, material fatigue. Infinity of lifetime*. All chemical reactions are acted through ORBITAL electron of atoms. The AB-Matter does not have orbital electrons (special cases will be considered later on). Nucleons cannot combine with usual atoms having electrons. In particular, the AB-Matter has *absolute corrosion resistance*. *No fatigue of material* because in conventional material fatigue is result of splits between material crystals. No crystals in AB-Matter. That means AB-Matter has lifetime equal to the lifetime of neutrons themselves. Finally a container for the universal solvent!

4. *Super-transparency, invisibility of special AB-Matter-nets*. An AB-Matter net having a step distance (mesh size) between strings or monofilaments of more than 100 fm = $10^{-13}$ m will pass visible light having the wave length (400 - 800)×$10^{-9}$ m. You can make cars, aircraft, and space ships from such a permeable AB-Matter net and you will see a man (who is made from conventional matter) apparently sitting on nothing, traveling with high speed in atmosphere or space without visible means of support or any visible vehicle! (Any fuel in fuel tanks would be visible also, however…)

5. *Impenetrability for gas, liquids, and solid bodies*. When the AB-Matter net has a step size between strings of less than atomic size of $10^{-10}$ m, it became impenetrable for conventional matter. Simultaneously it may be invisible for people and have gigantic strength. The AB-Matter net may – as armor--protect from gun, cannon shells and missiles.

6. *Super-impenetrability for radiation.* If the cell size of the AB-Matter net will be less than a wave length of a given radiation, the AB-Matter net does not pass this radiation. Because this cell size may be very small, AB net is perfect protection from any radiation up to soft gamma radiation (include radiation from nuclear bomb).

7. *Full reflectivity (super-reflectivity)*. If the cell size of an AB-Matter net will be less than a wavelength of a given radiation, the AB-Matter net will then fully reflect this radiation. With perfect reflection and perfect impenetrability remarkable optical systems are possible. A Fresnel like lens might also be constructible of AB-Matter.

8. *Permeable property (ghost-like intangibility power; super-passing capacity)*. The AB-Matter net from single strings having mesh size between strings of more than 100 nm = $10^{-11}$ m will pass the atoms and molecules through itself because the diameter of the single string ($2\times10^{-15}$ m) is 100 thousand times less then diameter of atom ($3\times10^{-10}$ m). That means that specifically engineered constructions from AB-Matter can be built on the Earth, but people will not see and feel them. The power to phase through walls, vaults, and barriers has occasionally been portrayed in science fiction but here is a real life possibility of it happening.

9. *Zero friction*. If the AB-Matter net has a mesh size distance between strings equals or less to the atom ($3\times10^{-10}$ m), it has an ideal flat surface. That means the mechanical friction may be zero. It is very important for aircraft, sea ships and vehicles because about 90% of its energy they spend in friction. Such a perfect surface would be of vast value in optics, nanotech molecular assembly and prototyping, physics labs, etc.

10. *Super or quasi-super electric conductivity at any temperature*. As it is shown in previous section the AB-Matter string can have outer electrons in an arrangement similar to the electronic cloud into metal. But AB-Matter strings (threads) can be located along the direction of the electric intensity and they will not resist the electron flow. That means the electric resistance will be zero or very small.

11. *High dielectric strength* (see (21)). AB-Matter may be used for devices to produce high magnetic intensity.

**Use of AB-Matter**. The simplest use of AB-Matter is strengthening and reinforcing conventional material by AB-Matter fiber. As it is shown in the 'Computation' section, AB-Matter fiber is stronger (has a gigantic ultimate tensile stress) than conventional material by a factor of millions of times, can endure millions degrees of temperature, and is invulnerable to any attacking chemical reactions. We can insert (for example, by casting around the reinforcement) AB-Matter fiber (or net) into steel, aluminum, plastic and the resultant matrix of conventional material increases in strength by thousands of times—if precautions are taken that the reinforcement stays put! Because of the extreme strength disparity design tricks must be used to assure that the fibers stay 'rooted'. The matrix form of conventional artificial fiber reinforcement is used widely in current technology. This increases the tensile stress resistance of the reinforced matrix matter by typically 2 – 4 times. Engineers dream about a nanotube reinforcement of conventional matrix materials which might increase the tensile stress by 10 – 20 times, but nanotubes are very expensive and researchers cannot decrease its cost to acceptable values yet despite years of effort.

Another way is using a construct of AB-Matter as a continuous film or net (fig. 5b,d). These forms of AB-Matter have such miraculous properties as invisibility, superconductivity, zero friction, etc. The ultimate in camouflage, installations of a veritable Invisible World can be built from certain forms of AB-Matter with the possibility of being also interpenetable, literally allowing ghost-like passage through an apparently solid wall. Or the AB-Matter net (of different construction) can be designed as an impenetrable wall that even hugely destructive weapons cannot penetrate.

The AB-Matter film and net may be used for energy storage which can store up huge energy intensities and used also as rocket engines with gigantic impulse or weapon or absolute armor (see computation and application sections). Note that in the case of absolute armor, safeguards must be in place against buffering sudden accelerations; g-force shocks can kill even though nothing penetrates the armor!

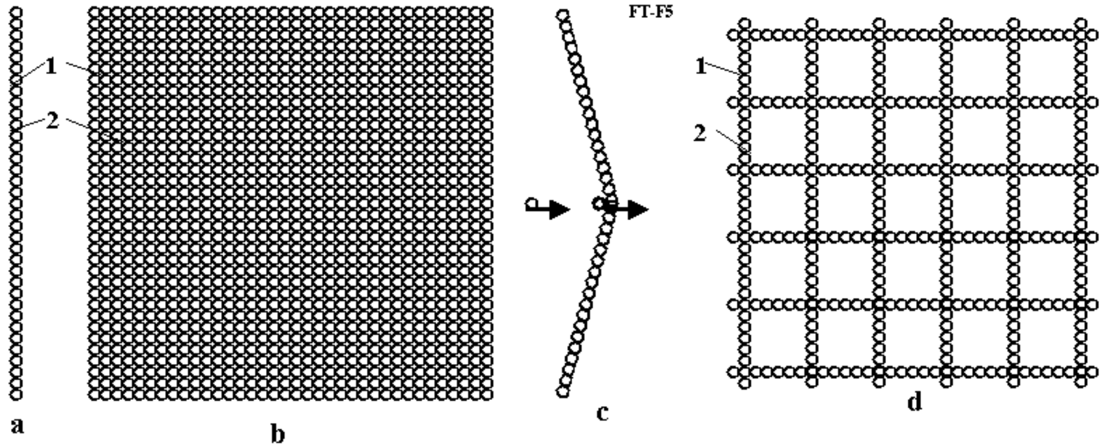
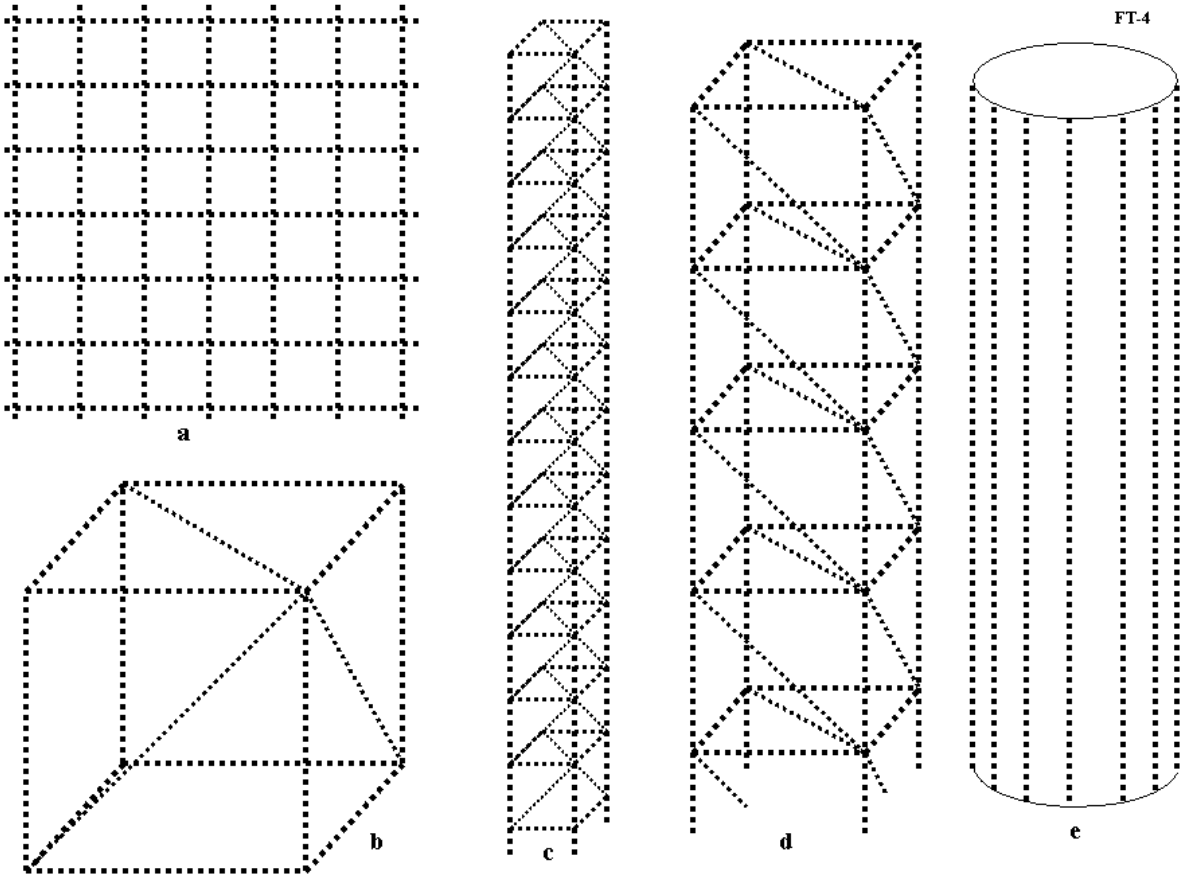



**Fig.5**. Thin film from nuclear matter. (**a**) cross-section of a matter film from single strings (side view); (**b**) continuous film from nuclear matter; (**c**) AB film under blow from conventional molecular matter; (**d**) – net from single strings. Notations: 1 – nucleons; 2 – electrons inserted into AB-Matter; 3 – conventional atom.

The AB-Matter net (which can be designed to be gas-impermeable) may be used for inflatable construction of such strength and lightness as to be able to suspend the weight of a city over a vast span the width of a sea. AB-Matter may also be used for cubic or tower solid construction as it is shown in fig.6.




1. **Fig.6.** Structures from nuclear strings. (**a**) nuclear net (netting, gauze); (**b**) cube from matter string; (**c**) primary column from nuclear string; (**d**) large column where elements made from primary columns; (**e**) tubes from matter string or matter columns.

The applications of the AB-Matter are encyclopedic in scope. This matter will create revolutions in many fields of human activity, transportation, energy, construction, security and even in c**omputer and computer memory**. The AB-Matter film allows to write in 1 cm$^2$ $N = 1/(4\times10^{-26})$ $= 2.5\times10^{25}$ 1/cm$^2$ bits information. The current 45 nanometer technology allows to write only $N =$ $2.5\times10^{14}$ 1/cm$^2$ bit. That means the main chip and memory of computer based in AB-Matter film may be a billion times smaller and presumably thousands of times faster (based on the lesser distance signals must travel).

**Some proposed technologies for producing AB-Matter**.

One method of producing AB-Matter may use the technology reminiscent of a computer chip fab (fig.4). One side of closed box 1 is evaporation mask 2. In the other size are located the sources of neutrons, charged nuclear particles (protons, charged nuclei and their connections) and electrons. Sources (guns) of charged particles have accelerators of particles and control their energy and direction. They concentrate (focus) particles, send particles (in beam form) to needed points with needed energy for overcoming the Coulomb barrier. The needed neutrons are received also from nuclear reactions and reflected by the containing walls.

Various other means are under consideration for generation of AB-Matter, what is certain however is, that once the first small amounts have been achieved, larger and larger amounts will be produced with ever increasing ease. Consider for example, that once we have achieved the ability to make a solid AB-Matter film (a sliced plane through a solid block of AB-Matter), and then developed the ability to place holes with precision through it one nucleon wide, a modified extrusion technique may produce AB-Matter strings (thin fiber), by passage of conventional matter in gas, liquid or solid state through the AB-Matter matrix (mask). This would be a 'femto-die'. Re-assembling these strings with perfect precision and alignment would produce more AB-Matter film; leaving deliberate gaps would reproduce the 'holes' in the initial 'femto-die'.

The developing of femtotechnology is easier, in one sense, than the developing of fully controllable nanotechnology because we have only three main particles (protons, neutrons, their ready combination of nuclei $_2$D, $_3$T, $_4$He, etc., and electrons) as construction material and developed methods of their energy control, focusing and direction.

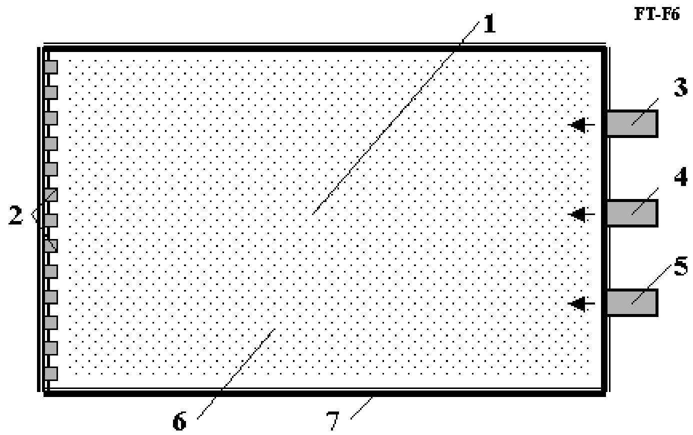



**Fig.4.** Conceptual diagram for installation producing AB-Matter. Notations: 1 – installation; 2 –AB-Matter (an extremely thin thread round bar, tube, net) and form mask; 3 – neutron source; 4 – source of charged particles (protons, charged nuclei), accelerator of charged particle, throttle control, beam control; 5 - source of electrons, accelerator of electrons, throttle control, beam control; 6 – cloud of particles; 7 – walls reflect the neutrons and utilize the nuclear energy.

# Discussion

**Contrast to nanotubes**

Strength

Carbon nanotubes are the strongest and stiffest materials yet discovered in terms of tensile strength and elastic modulus respectively. This strength results from the covalent $sp^2$ bonds formed between the individual carbon atoms. In 2000, a multi-walled carbon nanotube was tested to have a tensile strength of 63 gigapascals (GPa). Since carbon nanotubes have a low density for a solid of 1.3-1.4 g•cm$^{-3}$,[1] its specific strength of up to 48,000 kN•m•kg−1 is the best of known materials, compared to high-carbon steel's 154 kN•m•kg−1. According to our computations, if AB-Matter is stronger by a factor of $10^{23}$ times than steel (by 100 thousands billion by billions times!) and by $10^{22}$ times stronger than nanotubes (by 10 thousand billion by billions times!).

Kinetic

Multi-walled nanotubes, multiple concentric nanotubes precisely nested within one another, exhibit a striking telescoping property whereby an inner nanotube core may slide, almost without friction, within its outer nanotube shell thus creating an atomically perfect linear or rotational bearing. While nanotubes may slide “almost without friction” AB-Matter would slide without any friction making possible the first true perpetual motion machine.

Electrical

Because of the symmetry and unique electronic structure of graphene, the structure of a nanotube strongly affects its electrical properties. For a given (n,m) nanotube, if n = m, the nanotube is metallic; if n − m is a multiple of 3, then the nanotube is semiconducting with a very small band gap, otherwise the nanotube is a moderate semiconductor. Thus all armchair (n=m) nanotubes are metallic, and nanotubes (5,0), (6,4), (9,1), etc. are semiconducting. In theory, metallic nanotubes can carry an electrical current density of $4\times10^9$ A/cm$^2$ which is more than 1,000 times greater than metals such as copper[2].

Thermal

All nanotubes are expected to be very good thermal conductors along the tube, exhibiting a property known as "ballistic conduction," but good insulators laterally to the tube axis. It is predicted that carbon nanotubes will be able to transmit up to 6000 watts per meter per Kelvin at room temperature; compare this to copper, a metal well-known for its good thermal conductivity, which transmits 385 watts per meter per K. The temperature stability of carbon nanotubes is estimated to be up to 2800oC in vacuum and about 750oC in air. According to our computations, AB-Matter of the same form will have the temperature stability in Kelvin degrees is ($7\times10^{10}$K) which is 7 billion millions degrees. It is about 50 - 100 times more than temperature in a fusion nuclear reactor.

**Atoms and nuclei**.

There are four forces active between particles: strong interaction, weak interaction, electromagnetic charge force (Coulomb) and gravitational force. The nuclear force dominates at distances up to 2 fm (femtometers, (femto, 1 fm = $10^{-15}$ m). They are hundreds of times more powerful than the charge force and million-millions of times more powerful than gravitational force. Charge force is effective at distances over 2 fm.

Strong nuclear forces are anisotropic (non spherical, force distribution not the same in all directions equally), which means that they depend on the relative orientation of the nucleus. Typical nuclear energy (force) is presented in fig.1. When it is positive the nuclear force repels the other atomic particles (protons, neutrons, electrons). When nuclear energy is negative, it attracts them up to a distance of about 2 fm. The value r0 usually is taken as radius of nucleus. The computation of

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strong nuclear force - interaction energy of one nucleus via specific density of one nucleus in given point – is present in Fig.2. The solid line is as computed by Berkner's method [7] with 2 correlations, dotted line is computer generated with 3 correlations, square is experimental. Average interaction energy between to nucleus is about 8 MeV, distance where the attractive strong nuclear force activates is at about 1 – 1.2 fm

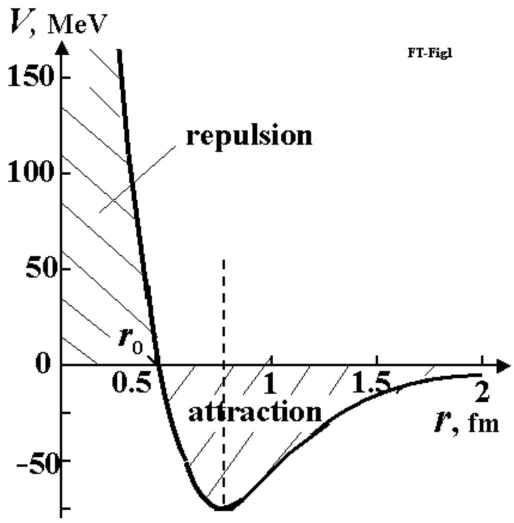


**Fig.1**. Typical nuclear force of nucleus. When nucleon is at distance of less than 1.8 fm, it is attracted to nucleus. When nucleon is very close, it is repulsed from nucleus. (Reference from http://www.physicu.narod.ru , Vol. 5 p. 670).

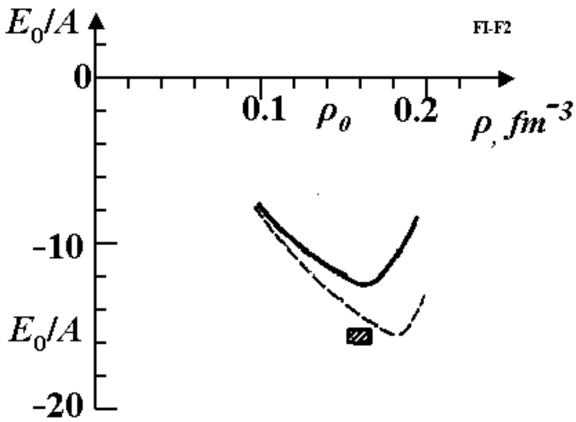


**Fig.2.** Connection (interaction) energy of one nucleon via specific density of one nucleon in given point. Firm line is computed by Berkner's method with 2 correlations, dotted line is computer with 3 correlations, square is experiment. (Reference from http://www.physicu.narod.ru , Vol. 5 p. 655).

While bound neutrons in stable nuclei are stable, outside the nucleus, free neutrons are unstable and have a mean lifetime of 885.7±0.8 s, decaying by emission of a negative electron and antineutrino to become a proton:

$$n^0 \to p^+ + e^- + \nu_e .$$

This decay mode, known as beta decay, can also transform the character of neutrons within unstable nuclei. Bound inside a nucleus, protons can also transform via inverse beta decay into neutrons. In this case, the transformation occurs by emission of a positron (anti-electron) and a neutrino (instead of an antineutrino):

$$p^+ \to n^0 + e^+ + \nu_e .$$

When bound inside of a nucleus, the instability of a single neutron to beta decay is balanced

against the instability that would be acquired by the nucleus as a whole if an additional proton were to participate in repulsive interactions with the other protons that are already present in the nucleus. As such, although free neutrons are unstable, bound neutrons are not necessarily so. The same reasoning explains why protons, which are stable in empty space, may transform into neutrons when bound inside of a nucleus. A thermal neutron is a free neutron that is Boltzmann distributed with kT = 0.024 eV ($4.0\times10^{-21}$ J) at room temperature. This gives characteristic, not average, or median speed of 2.2 km/s. Four forces active between particles: strong interaction, weak interacting, charge force (Coulomb force) and gravitation force. The strong interaction is the most strong force in short nuclei distance, the gravitation is very small into atom. Beta decay and electron capture are types of radioactive decay and are both governed by the weak interaction.

**Basic properties of the nuclear force.**

The nuclear force is only felt among hadrons, a bound state of quarks or particles into nucleous. Hadrons are held together by the strong force, similarly to how atoms are held together by the electromagnetic force. There are two subsets of hadrons: baryons and mesons; the most well known baryons are protons and neutrons. At much smaller separations between nucleons the force is very powerfully repulsive, which keeps the nucleons at a certain average separation. Beyond about 1.7 femtometer (fm) separation, the force drops to negligibly small values. At short distances, the nuclear force is stronger than the Coulomb force; it can overcome the Coulomb repulsion of protons inside the nucleus. However, the Coulomb force between protons has a much larger range and becomes the only significant force between protons when their separation exceeds about 2.5 fm. The nuclear force is nearly independent of whether the nucleons are neutrons or protons. This property is called charge independence. It depends on whether the spins of the nucleons are parallel or antiparallel, and has a noncentral or tensor component. This part of the force does not conserve orbital angular momentum, which is a constant of motion under central forces.

## Degenerate matter.

Degenerate matter is matter which has such very high density that the dominant contribution to its pressure rises from the Pauli Exclusion Principle. The pressure maintained by a body of degenerate matter is called the degeneracy pressure, and arises because the Pauli principle forbids the constituent particles to occupy identical quantum states. Any attempt to force them close enough together that they are not clearly separated by position must place them in different energy levels. Therefore, reducing the volume requires forcing many of the particles into higher-energy quantum states. This requires additional compression force, and is manifest as a resisting pressure. Imagine that there is plasma, and it is cooled and compressed repeatedly. Eventually, we will not be able to compress the plasma any further, because the Exclusion Principle states that two particles cannot be in the exact same place at the exact same time. When in this state, since there is no extra space for any particles, we can also say that a particle's location is extremely defined. Therefore, since (according to the Heisenberg Uncertainty Principle) $\Delta p \Delta x = \hbar/2$ where $\Delta p$ is the uncertainty in the particle's momentum and $\Delta x$ is the uncertainty in position, then we must say that their momentum is extremely uncertain since the molecules are located in a very confined space. Therefore, even though the plasma is cold, the molecules must be moving very fast on average. This leads to the conclusion that if you want to compress an object into a very small space, you must use tremendous force to control its particles' momentum.

Unlike a classical ideal gas, whose pressure is proportional to its temperature ($PV = NkT$, where $P$ is pressure, $V$ is the volume, $N$ is the number of particles (typically atoms or molecules), $k$ is Boltzmann's constant, and $T$ is temperature), the pressure exerted by degenerate matter depends only weakly on its temperature. In particular, the pressure remains nonzero even at absolute zero temperature. At relatively low densities, the pressure of a fully degenerate gas is given by $P = Kn^{5/3}$, where $K$ depends on the properties of the particles making up the gas. At very high densities, where most of the particles are forced into quantum states with relativistic energies, the pressure is given by $P = K'n^{4/3}$, where $K'$ again depends on the properties of the particles making up the gas.

Degenerate matter still has normal thermal pressure, but at high densities the degeneracy pressure dominates. Thus, increasing the temperature of degenerate matter has a minor effect on total pressure until the temperature rises so high that thermal pressure again dominates total pressure. Exotic examples of degenerate matter include neutronium, strange matter, metallic hydrogen and white dwarf matter. Degeneracy pressure contributes to the pressure of conventional solids, but these are not usually considered to be degenerate matter as a significant contribution to their pressure is provided by the interplay between the electrical repulsion of atomic nuclei and the screening of nuclei from each other by electrons allocated among the quantum states determined by the nuclear electrical potentials. In metals it is useful to treat the conduction electrons alone as a degenerate, free electron gas while the majority of the electrons are regarded as occupying bound quantum states. This contrasts with the case of the degenerate matter that forms the body of a white dwarf where all the electrons would be treated as occupying free particle momentum states.

## Pauli principle

The **Pauli exclusion principle** states that no two identical fermions may occupy the same quantum state *simultaneously*. A more rigorous statement of this principle is that, for two identical fermions, the total wave function is anti-symmetric. For electrons in a single atom, it states that no two electrons can have the same four quantum numbers, that is, if $n$, $l$, and $m_l$ are the same, $m_s$ must be different such that the electrons have opposite spins. In relativistic quantum field theory, the Pauli principle follows from applying a rotation operator in imaginary time to particles of half-integer spin. It does not follow from any spin relation in nonrelativistic quantum mechanics.

The Pauli exclusion principle is one of the most important principles in physics, mainly because the three types of particles from which ordinary matter is made—electrons, protons, and neutrons—are all subject to it; consequently, all material particles exhibit space-occupying behavior. The Pauli exclusion principle underpins many of the characteristic properties of matter from the large-scale stability of matter to the existence of the periodic table of the elements. Particles with anti-symmetric wave functions are called fermions—and obey the Pauli exclusion principle. Apart from the familiar electron, proton and neutron, these include neutrinos and quarks (from which protons and neutrons are made), as well as some atoms like helium-3. All fermions possess "half-integer spin", meaning that they possess an intrinsic angular momentum whose value is $\hbar = h/2\pi$(Planck's constant divided by 2π) times a half-integer (1/2, 3/2, 5/2, etc.). In the theory of quantum mechanics, fermions are described by "anti-symmetric states", which are explained in greater detail in the theory on identical particles. Particles with integer spin have a symmetric wave function and are called bosons; in contrast to fermions, they may share the same quantum states. Examples of bosons include the photon, the Cooper pairs responsible for superconductivity, and the W and Z bosons.

A more rigorous proof was provided by Freeman Dyson and Andrew Lenard in 1967, who considered the balance of attractive (electron-nuclear) and repulsive (electron-electron and nuclear-nuclear) forces and showed that ordinary matter would collapse and occupy a much smaller volume without the Pauli principle.

Neutrons are the most "rigid" objects known - their Young modulus (or more accurately, bulk modulus) is 20 orders of magnitude larger than that of diamond. For white dwarfs the degenerate particles are the electrons while for neutron stars the degenerate particles are neutrons. In degenerate gas, when the mass is increased, the pressure is increased, and the particles become spaced closer together, so the object becomes smaller. Degenerate gas can be compressed to very high densities, typical values being in the range of $10^7$ grams per cubic centimeter.

**Pauli exclusion principle and Heisenberg Uncertainty Principle**. **General Question of Stability.**

One may question the compatibility of the Pauli exclusion principle and Heisenberg Uncertainty Principle with AB-Matter. The uncertainty principle is

$$\Delta p \Delta x \geq \hbar / 2 \qquad (27)$$

where $\Delta p = mV$ is momentum of particle, kg·m/s; $m$ is mass particles, kg; $V$ is speed particles, m/s; $\Delta x$ is distance between particles, m; $\hbar = 6.6262\times10^{-34}/2\pi$ is Planck's constant.

Pauli states that no two identical fermions may occupy the same quantum state *simultaneously*. A more rigorous statement of this principle is that, for two identical fermions, the total wave function is anti-symmetric. For electrons in a single atom, it states that no two electrons can have the same four quantum numbers, that is, if particles characteristics $n$, $l$, and $m_l$ are the same, $m_s$ must be different such that the electrons have opposite spins.

The uncertainty principle gives a high uncertainty of Δp for nucleons and very high uncertainty for electrons into AB-Matter. But high density matter (of the same order as our suggested AB-Matter) EXISTS in the form of nuclei of conventional matter and on neutron stars. That is an important proof - this matter exists. Some may question its' ability to stay in a super dense state passively. Some may doubt its' stability free of the fierce gravitation of neutron stars (natural degenerate matter) or outside the confines of the nucleus. But there are reasons, not all stated here, to suppose that it might be so stable under normal conditions.

One proof was provided by Freeman Dyson [11] and Andrew Lenard in 1967, who considered the balance of attractive (electron-nuclear) and repulsive (electron-electron and nuclear-nuclear) forces and showed that ordinary matter would collapse and occupy a much smaller volume without the Pauli principle. Certainly, however this very question of stability will be a key focus of any detailed probe into the possibilities of AB-Matter.

## Conclusion

The author offers a design for a new form of nuclear matter from nucleons (neutrons, protons), electrons, and other nuclear particles. He shows that the new AB-Matter has most extraordinary properties. For example, in varying forms it has remarkable tensile strength, stiffness, hardness, critical temperature, superconductivity, super-transparency, ghostlike ability to pass through matter, zero friction, etc., which are millions of times better than corresponded properties of conventional molecular matter including nanotubes. He shows how to design aircraft, ships, transportation, thermonuclear reactors, and constructions, and so on from this new nuclear matter. These vehicles will have correspondingly amazing possibilities (invisibility, passing through any walls and amour, protection from nuclear bombs and any radiation, etc).

Nanotechnology, in near term prospect, operates with objects (molecules and atoms) having the size in nanometer ($10^{-9}$ m). The author here outlines perhaps more distant operations with objects (nuclei) having size in the femtometer range, ($10^{-15}$ m, millions of times less smaller than the nanometer scale). The name of this new technology is femtotechnology.

Researching and developing femtotechnology may progress more quickly than the further prospects of nanotechnology, because we have fewer (only 3) initial components (proton, neutron, and electron) and interaction between them is well-known (3 main forces: strong, weak, and electrostatic). The different conventional atoms number about 100, most common molecules are tens thousands and interactions between them are very complex (e.g. Van der Waals force). It may be however, that nano and femto technology enable each other as well, as tiny bits of AB-Matter would be marvelous tools for nanomechanical systems to wield to obtain effects unimaginable otherwise.

### *Acknowledgement*

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